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Design and analysis of a multi-candidate selection scheme for greedy routing in wireless sensor networks

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ABSTRACT

Sleep and wake-up scheduling of sensor nodes is an efficient solution to prolong the network lifetime. However, existing scheduling algorithms may significantly decrease the number of active nodes so that the network may be intermittently connected. In such networks, traditional geographic routing protocols are inappropriate to obtain low latency routes due to route discovery and data forwarding latency. In this paper, we propose a novel *multi-candidate selection* (MCS) scheme for greedy routing that makes the best effort to find minimum latency routes in the sensor networks. In MCS, each source node sends an RREQ to a list of first wake-up forwarder candidates and selects a route with minimum estimated delivery latency based on their replies. The route found by MCS may be longer than that of *distance-based greedy forwarding* (DGF) (Finn, 1987). Hence, we introduce a *latency-adaptive distance-based multi-candidate selection* scheme for greedy forwarding to find routes with a small number of hops and acceptable delivery latency. Probabilistic analysis and simulation results demonstrate that MCS increases the routing performance significantly compared with DGF and ODML (Su et al., 2008) in terms of delivery latency.

1. Introduction

Wireless sensor networks (WSNs) are composed of a large number of sensor nodes and in general, they are deployed in inaccessible and hostile environments, *e.g.*, dense jungles, battle-fields, and inside phenomenon such as air flow around aircrafts, river flows, oceanic and atmospheric currents, etc. (Akyildiz et al., 2002; Yan et al., 2003; Gui and Mohapatra, 2004; Ha et al., 2009). Sensor nodes are often powered by batteries that may not be recharged. Meanwhile, many sensor network applications need to last for a long time. An efficient solution to achieve this goal is to densely deploy sensor nodes and schedule them to sleep and work (Gu and He, 2007; Wang et al., 2003; Cao et al., 2005; Cardei et al., 2005). This helps sensor nodes reduce communication overhead and sensing duty cycles. The scheduling scheme significantly decreases the number of active nodes for a given time unit, thereby prolonging the network lifetime. However, decreasing the number of active nodes may cause the network to be intermittently connected. In sensor networks with such a scheduling mechanism, traditional routing protocols, *e.g.*, *distance-based greedy forwarding* (DGF) (Finn, 1987), may not be able to find routes with low latency that is a mandatory requirement in many applications such as military surveillance and forest alarms.

The problem of finding routes with minimum latency in the intermittently connected WSN has been studied in the literature. Su et al. (2008) proposed an *on-demand minimum latency* (ODML) routing algorithm to find routes with minimum latency. In ODML, the source node finds a route by sending a route request (RREQ) to its neighbors. When an intermediate node receives an RREQ, it also forwards the RREQ to its neighbors. These steps are repeated until the RREQ reaches the destination node. Clearly, the first RREQ arriving at the destination goes through the smallest latency route. The destination node then responds with a route reply (RREP) to the source node. Because all nodes are scheduled to work and sleep, RREP may take a long time to travel back to the source node. Consequently, the end-to-end delivery latency which is the sum of route discovery and data transmission latencies, might become much larger. In addition, ODML has a high routing overhead. These issues worsen in the case that the working-duty cycle of nodes decreases or the network size increases.

In this paper, we propose a novel *multi-candidate selection* (MCS) scheme for greedy routing that makes the best effort to find minimum latency routes in intermittently connected WSN. This work is a revised and more thorough study than the earlier version of our work (Nguyen et al., 2010). The enhancements of this extended version are:

- Proposing a *latency-adaptive distance-based multi-candidate selection* (LDMS) scheme for greedy forwarding to find routes with a small number of hops and acceptable delivery latency.

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